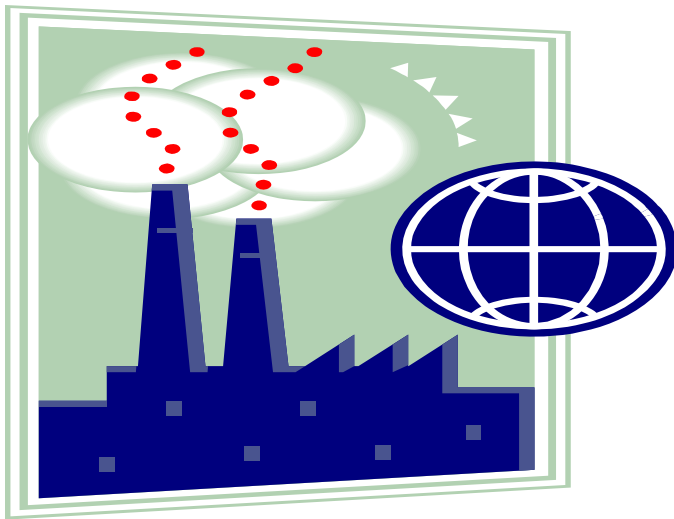


AERSURFACE Tool: Status and Update



Roger W. Brode
U.S. EPA, OAQPS
Air Quality Modeling Group
Research Triangle Park, NC

9th Conference on Air Quality Modeling
October 9, 2008
Research Triangle Park, NC

Outline

- Review of current AERSURFACE Tool
- Implementation Issues with AERSURFACE
- Plans for enhancing AERSURFACE
- Summary

AERMOD Met Data Needs

- AERMOD designed to accept same meteorological data as ISCST3: NWS surface and upper air data
- AERMOD also designed to accept more robust on-site meteorological data, including multi-level profiles of wind, temperature and turbulence
- However, more advanced boundary layer algorithms in AERMOD require user-specified surface characteristics:
 - Albedo
 - Bowen ratio
 - Surface roughness
- Sensitivity to surface characteristics is one of the main implementation issues with AERMOD

What is AERSURFACE?

- *AERSURFACE* is a tool designed to assist with determining surface characteristics data (albedo, Bowen ratio & surface roughness) for use in AERMET and/or AERSCREEN
- Initial version of *AERSURFACE* was released on SCRAM on January 11, 2008
- *AERSURFACE* is not currently considered part of the AERMOD regulatory modeling system

AERSURFACE Design

- AERSURFACE incorporates recent changes to method for estimating surface characteristics from land cover data, presented in latest *AERMOD Implementation Guide*, also posted in January 2008
- Revisions to calculating area-weighted averages for surface roughness:
 - Inverse-distance weighting to account for increased width/area of sector with distance
- Revisions to calculation methods:
 - Averaging $\ln(z_o)$ for surface roughness (= geometric mean)
 - Geometric mean for Bowen ratio
- Revisions to default domain/distances:
 - 1km radius for roughness
 - 10x10km domain for Bowen ratio and albedo – no sector or distance dependence

AERSURFACE Design

- Default values/functions with several user choices:
 - Number of sectors (up to 12)
 - Output monthly, seasonal, or annual data
 - Wet/dry/normal conditions for Bowen ratio
 - Snow vs. no snow cover
 - Arid vs. Non-arid
 - Airport vs. Non-airport location
- Current version of AERSURFACE supports 1992 National Land Cover Data (NLCD) files, with 21 categories at 30 meter horizontal resolution

1992 NLCD Land Cover Categories

Table 1: USGS NLCD 92 Land Use Categories

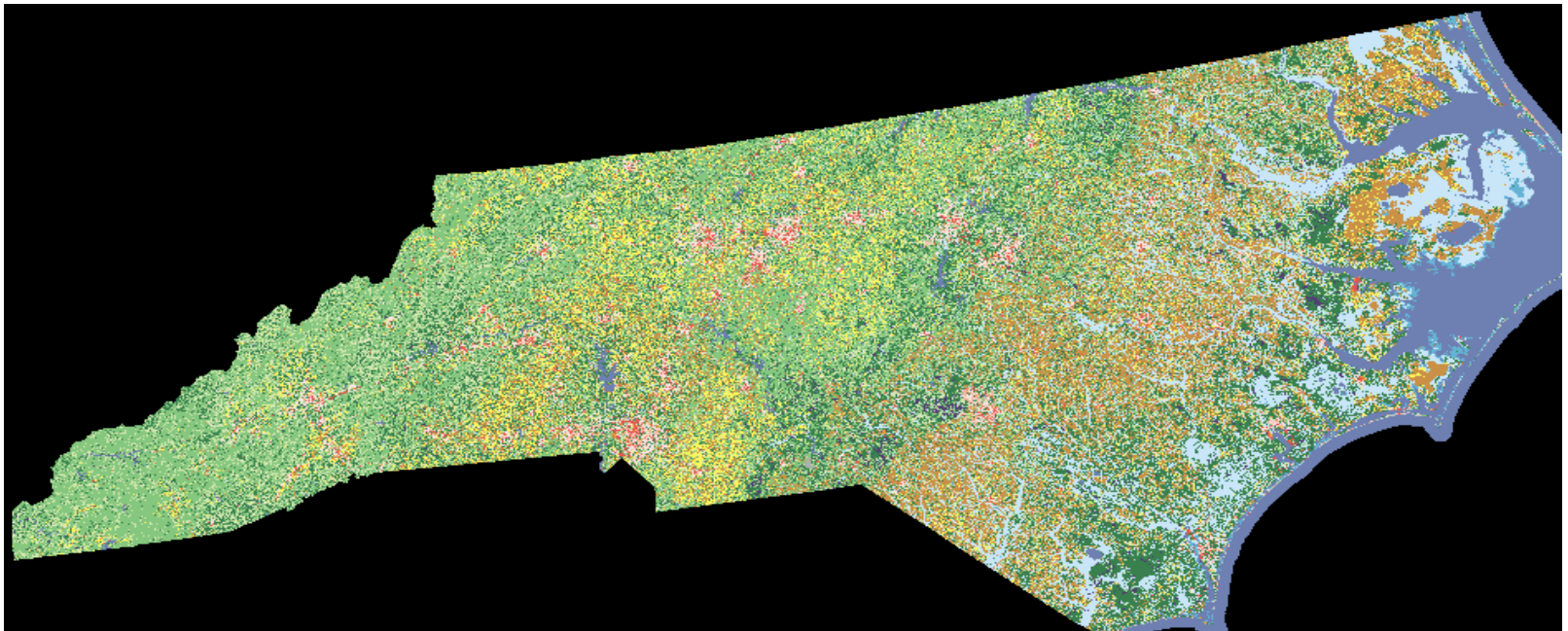
Classification Class	Land Use Category
Water	Open Water
	Perennial Ice/Snow
Developed	Low Intensity Residential
	High Intensity Residential
	Commercial/Industrial/Transportation
Barren	Bare Rock/Sand/Clay
	Quarries/Strip Mines/Gravel Pits
	Transitional
Forested Upland	Deciduous Forest
	Evergreen Forest
	Mixed Forest
Shrubland	Shrubland
Non-natural Woody	Orchards/Vineyards/Other
Herbaceous Upland	Grasslands/Herbaceous
Herbaceous Planted/Cultivated	Pasture/Hay
	Row Crops
	Small Grains
	Fallow
	Urban/Recreational Grasses
Wetlands	Woody Wetlands
	Emergent Herbaceous Wetlands

AERSURFACE Surface Characteristics

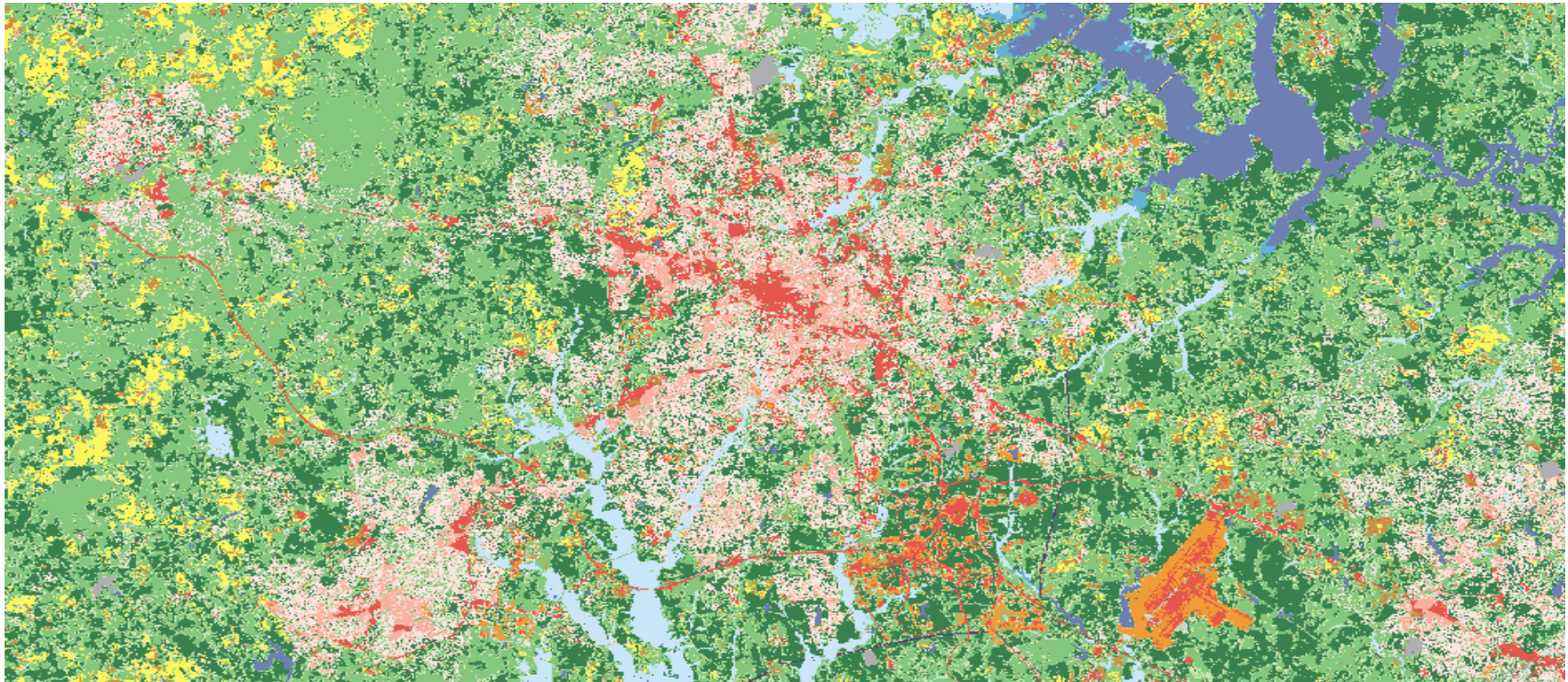
Class Number	Class Name	Seasonal Surface Roughness ¹ (m)					Reference(s)
		1	2	3	4	5	
11	Open Water	0.001	0.001	0.001	0.001	0.001	Stull ²
12	Perennial Ice/Snow	0.002	0.002	0.002	0.002	0.002	Stull ²
21	Low Intensity Residential	0.54	0.54	0.50	0.50	0.52	40% 22 + 50% 43+ 10% 85 ³
22	High Intensity Residential	1	1	1	1	1	AERMET ⁴
23	Commercial/Industrial/Transport (Site at Airport)	0.1	0.1	0.1	0.1	0.1	5%: 22 & 95%: 31 ⁵
	Commercial/Industrial/Transport (Not at Airport)	0.8	0.8	0.8	0.8	0.8	80%: 22 & 20%: 31 ⁵
31	Bare Rock/Sand/Clay (Arid Region)	0.05	0.05	0.05	NA	0.05	Slade ⁶
	Bare Rock/Sand/Clay (Non-arid Region)	0.05	0.05	0.05	0.05	0.05	Slade ⁶
32	Quarries/Strip Mines/Gravel	0.3	0.3	0.3	0.3	0.3	Estimate ⁷
33	Transitional	0.2	0.2	0.2	0.2	0.2	Estimate ⁸
41	Deciduous Forest	1.3	1.3	0.6	0.5	1	AERMET ⁴
42	Evergreen Forest	1.3	1.3	1.3	1.3	1.3	AERMET ⁴
43	Mixed Forest	1.3	1.3	0.95	0.9	1.15	(41+42)/2 ⁹
51	Shrubland (Arid Region)	0.15	0.15	0.15	NA	0.15	50% 51 (Non-Arid) ¹⁰
	Shrubland (Non-arid Region)	0.3	0.3	0.3	0.15	0.3	AERMET ⁴
61	Orchards/Vineyards/Other	0.3	0.3	0.1	0.05	0.2	Garratt ¹¹
71	Grasslands/Herbaceous	0.1	0.1	0.01	0.005	0.05	AERMET ⁴
81	Pasture/Hay	0.15	0.15	0.02	0.01	0.03	Garratt ¹¹ & Slade ¹²
82	Row Crops	0.2	0.2	0.02	0.01	0.03	Garratt ¹¹ & Slade ¹²
83	Small Grains	0.15	0.15	0.02	0.01	0.03	Garratt ¹¹ & Slade ¹²
84	Fallow	0.05	0.05	0.02	0.01	0.02	31 & 81,82,83 ¹³
85	Urban/Recreational Grasses	0.02	0.015	0.01	0.005	0.015	Randerson ¹⁴
91	Woody Wetlands	0.7	0.7	0.6	0.5	0.7	(43+92)/2 ¹⁵
92	Emergent Herbaceous Wetlands	0.2	0.2	0.2	0.1	0.2	AERMET ⁴

¹ Values are listed for the following seasonal categories: 1 - Midsummer with lush vegetation; 2 - Autumn with unharvested cropland; 3 - Late autumn after frost and harvest; or winter with no snow; 4 - Winter with continuous snow on ground; 5 - Transitional spring with partial green coverage or short annuals

USGS NLCD 1992 Example Data



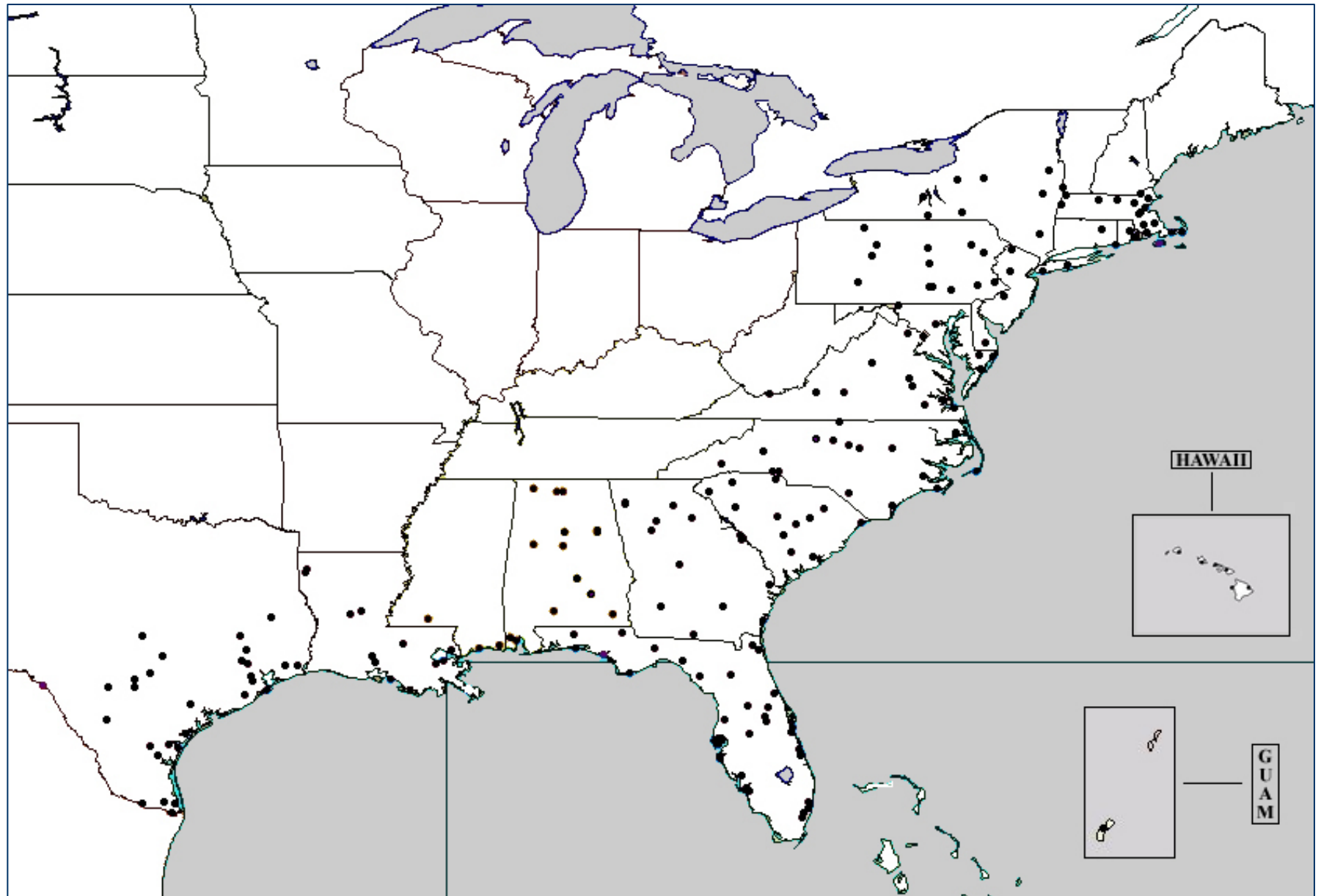
USGS NLCD 1992 Example Data



Potential AERSURFACE Issue

- Uncertainties regarding ASOS met station locations – a key AERSURFACE input
 - Excel file with ASOS station locations available on NCDC website is unreliable for location information
 - Additional data available for about 200 ASOS stations as part of tropical cyclone wind study appears to be (generally) reliable
 - Many locations off by several hundred meters (median value of about 500m)
 - For example, RDU tower location is off by over 2km!
 - Use of erroneous station locations in AERSURFACE could invalidate results

ASOS Met Station Locations – Cyclone Wind Study



ASOS Met Station Locations

Comparison of ASOS Station Locations from Two References

Call	WBAN	NCDC ASOS List		ASOS Cyclone Wind Study		Delta-Lat	Delta-Lon	Dist (km)	ST	Station Name
		Lat-ASOS	Lon-ASOS	Lat-PHOTO	Lon-PHOTO					
KIJD	54767	41.7419	72.1836	41.7420	72.1830	0.000	0.001	0.061	CT	Willimantic Windham Airport
KAQW	54768	42.6958	73.1708	42.6970	73.1700	-0.001	0.001	0.143	MA	North Adams Harriman
KBED	14702	42.4700	71.2894	42.4680	71.2940	0.002	-0.005	0.498	MA	Bedford Hanscom Field
KBOS	14739	42.3606	71.0106	42.3590	71.0200	0.002	-0.009	0.956	MA	Boston Logan Intl Airport
KBVY	54733	42.5842	70.9175	42.5840	70.9160	0.000	0.002	0.151	MA	Beverly Municipal Airport
KCQX	94624	41.6875	69.9933	41.6880	69.9930	-0.001	0.000	0.060	MA	Chatham Municipal Airport
KEWB	94726	41.6764	70.9583	41.6750	70.9570	0.001	0.001	0.193	MA	New Bedford Municipal Airport
KFIT	4780	42.5519	71.7558	42.5520	71.7560	0.000	0.000	0.017	MA	Fitchburg Municipal Airport
KHYA	94720	41.6686	70.2800	41.6690	70.2710	0.000	0.009	0.900	MA	Hyannis Barnstable Municipal Airport
KMVY	94724	41.3931	70.6150	41.3920	70.6170	0.001	-0.002	0.226	MA	Martha's Vineyard Airport
KORE	54756	42.5700	72.2911	42.5720	72.2780	-0.002	0.013	1.327	MA	Orange Municipal Airport
KOWD	54704	42.1908	71.1736	42.1910	71.1740	0.000	0.000	0.042	MA	Norwood Memorial Airport
KPYM	54769	41.9097	70.7294	41.9070	70.7280	0.003	0.001	0.308	MA	Plymouth Municipal Airport
KTAN	54777	41.8756	71.0211	41.8760	71.0210	0.000	0.000	0.046	MA	Taunton Municipal Airport
KFWN	54793	41.2003	74.6231	41.2000	74.6170	0.000	0.006	0.606	NJ	Sussex Airport
KSMQ	54785	40.6239	74.6694	40.6170	74.6670	0.007	0.002	0.731	NJ	Somerville Somerset Airport
KVAY	93780	39.9406	74.8411	39.9500	74.8500	-0.009	-0.009	1.297	NJ	Mount Holly South Jersey Regional Airport
KALB	14735	42.7481	73.8033	42.7470	73.7990	0.001	0.004	0.446	NY	Albany County Airport
KBGM	4725	42.2078	75.9814	42.2070	75.9800	0.001	0.001	0.159	NY	Binghamton Regional Airport
KELM	14748	42.1594	76.8919	42.1570	76.9030	0.002	-0.011	1.132	NY	Elmira Corning Regional Airport
KGFL	14750	43.3411	73.6103	43.3380	73.6100	0.003	0.000	0.312	NY	Glens Falls Airport
KISP	4781	40.7939	73.1017	40.8000	73.1000	-0.006	0.002	0.634	NY	Islip Long Island Macarthur Airport
KJFK	94789	40.6553	73.7956	40.6330	73.7670	0.022	0.029	3.622	NY	New York J F Kennedy Intl Airport
KPEO	54778	42.6425	77.0564	42.6440	77.0530	-0.002	0.003	0.370	NY	Penn Yan Airport
KPOU	14757	41.6267	73.8842	41.6260	73.8820	0.001	0.002	0.226	NY	Poughkeepsie Dutchess Co Airport
KPSF	14763	42.4272	73.2892	42.4170	73.2890	0.010	0.000	1.022	NY	Pittsfield Municipal Airport
KSYR	14771	43.1092	76.1033	43.1110	76.1040	-0.002	-0.001	0.195	NY	Syracuse Hancock Intl Airport
KUCA	94794	43.1450	72.3839	43.1440	75.3840	0.001	-3.000	300.011	NY	Utica Oneida County Airport
KPVD	14765	41.7219	71.4325	41.7230	71.4330	-0.001	-0.001	0.117	RI	Providence Green State Airport
KUUU	14787	41.5300	71.2836	41.5300	71.2840	0.000	0.000	0.039	RI	Newport State Airport
KWST	14794	41.3497	71.7989	41.3500	71.7990	0.000	0.000	0.030	RI	Westerly State Airport
KDDH	54781	42.8914	73.2469	42.8940	73.2490	-0.003	-0.002	0.332	VT	Bennington Morse State Airport

Future Plans for AERSURFACE

- Enhance AERSURFACE to support 2001 NLCD data; includes Alaska
 - Draft Beta-test version completed and being reviewed by RO's and AIWG; should be released on SCRAM soon
- Beta-test version also includes more robust GeoTIFF “Reader” to support wider range of data formats/structures (also in AERMAP for NED data)
- Supplement NLCD data with estimate of average height of obstacles derived from NED and SRTM elevation data
 - NLCD categories (both 1992 and 2001) are not ideal for estimating surface roughness at airports

NLCD 2001 Land Cover Class Definitions

11. Open Water

12. Perennial Ice/Snow

21. Developed, Open Space - Areas with some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.

22. Developed, Low Intensity - Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover.

23. Developed, Medium Intensity - Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover.

24. Developed, High Intensity - Highly developed areas, includes apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80-100 percent of the total cover.

31. Barren Land (Rock/Sand/Clay)

32. Unconsolidated Shore

41. Deciduous Forest

42. Evergreen Forest

43. Mixed Forest

51. Dwarf Scrub

52. Shrub/Scrub

71. Grassland/Herbaceous

72. Sedge/Herbaceous

73. Lichens

74. Moss

81. Pasture/Hay

82. Cultivated Crops

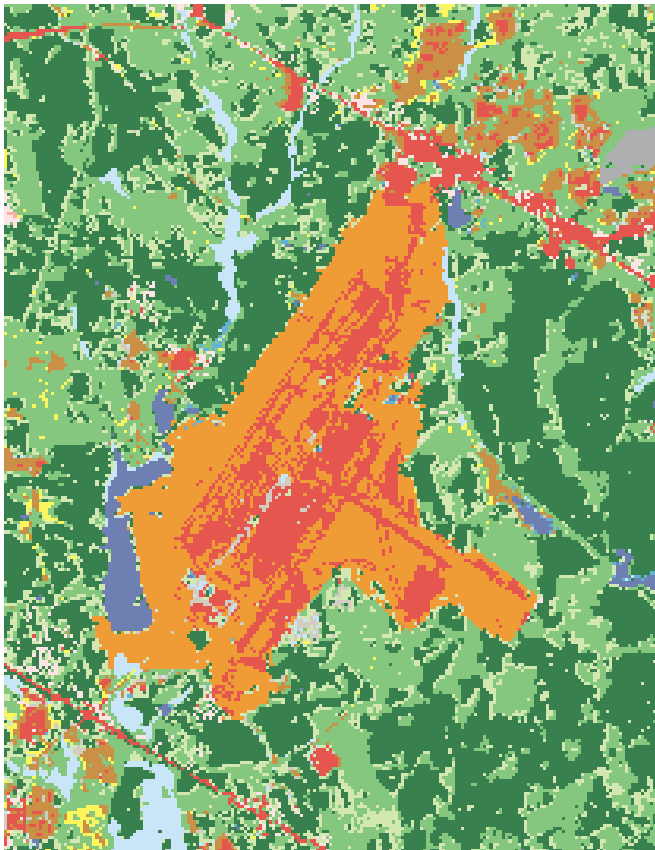
90. Woody Wetlands (with additional breakdown for coastal areas)

95. Emergent Herbaceous Wetlands (with additional breakdown for coastal areas)

NLCD 1992 vs. NLCD 2001 for RDU

1992 Data

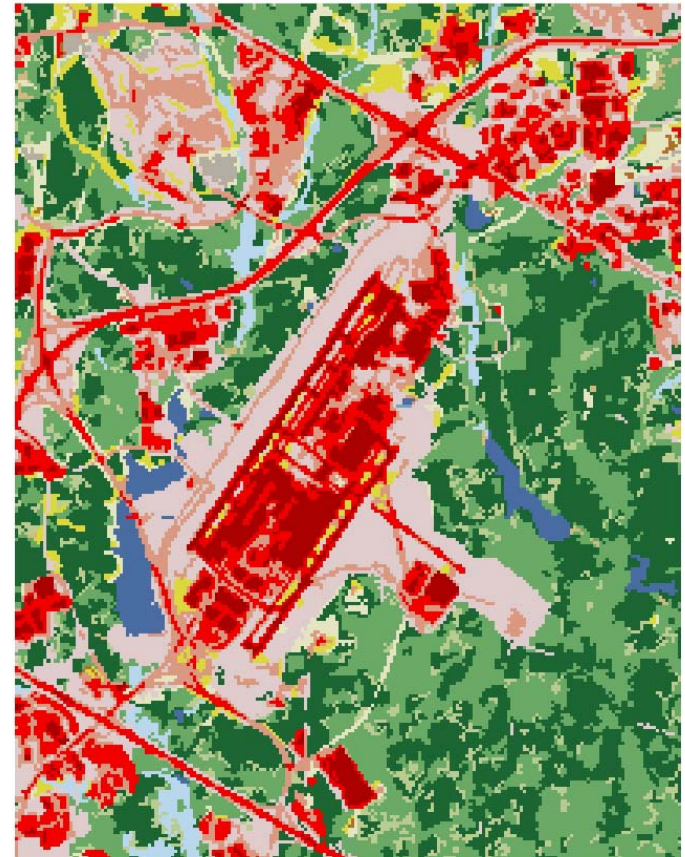
- Open Water
- Perennial Ice/Snow
- Low Intensity Residential
- High Intensity Residential
- Commercial/Industrial/Transportation
- Bare Rock/Sand/Clay
- Quarries/Strip Mines/Gravel Pits
- Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Orchards/Vineyards/Other
- Grasslands/Herbaceous
- Pasture/Hay
- Row Crops
- Small Grains
- Fallow
- Urban/Recreational Grasses
- Woody Wetlands
- Emergent Herbaceous Wetlands



2001 Data

Legend

- 11
- 21
- 22
- 23
- 24
- 31
- 41
- 42
- 43
- 52
- 71
- 81
- 82
- 90
- 95

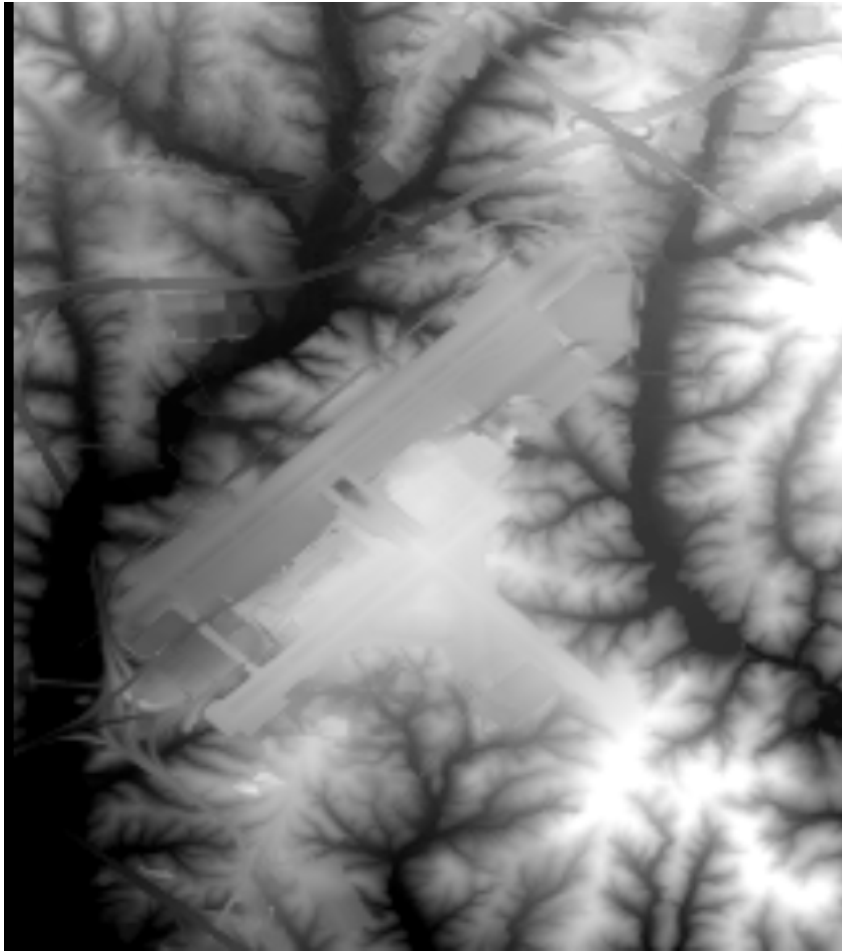


Future Plans for AERSURFACE

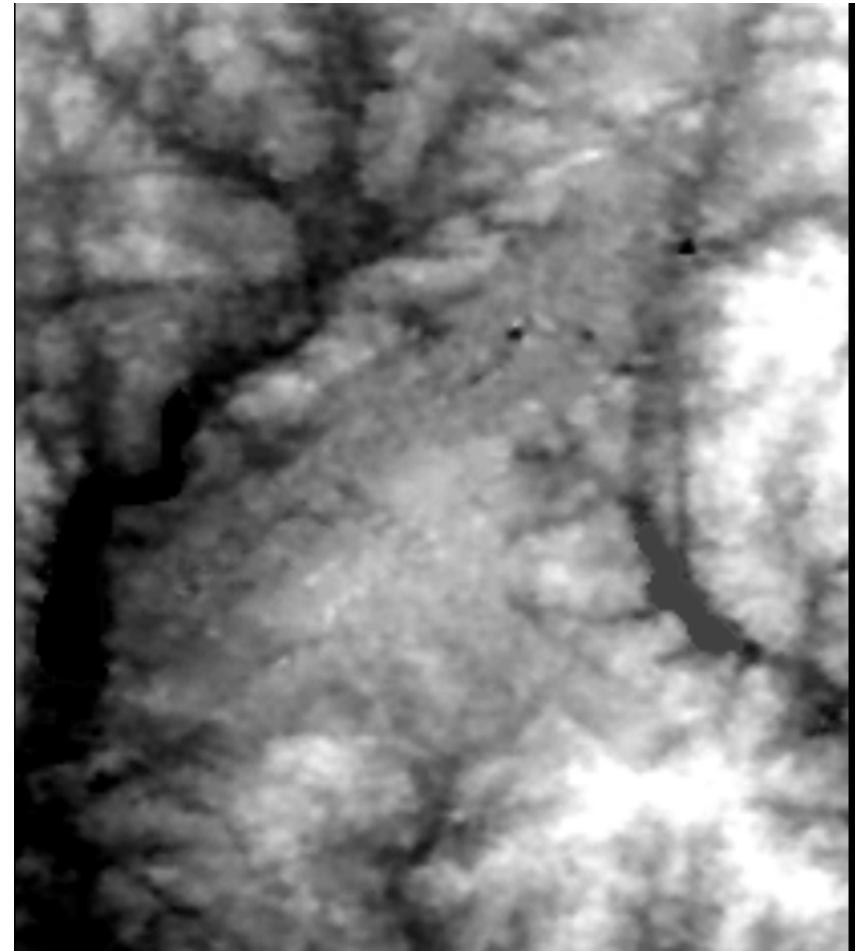
- NED and SRTM elevation data are both available at 1-sec (~30m) horizontal resolution for most of U.S. (no SRTM in northern AK)
 - Same resolution as NLCD data
 - NED represents ground elevations
 - SRTM represents elevations of obstacles:
 - “The elevation data are with respect to the reflective surface, which may be vegetation, man-made features or bare earth.” (USGS Product Description)
- Coupling estimates of average height of obstacles with NLCD data should facilitate better estimates of surface roughness
 - Allows for distinguishing between “highly developed” grid cells (based on impervious land cover fraction) that are runways vs. buildings

NED vs. SRTM Elevations for RDU

NED Data

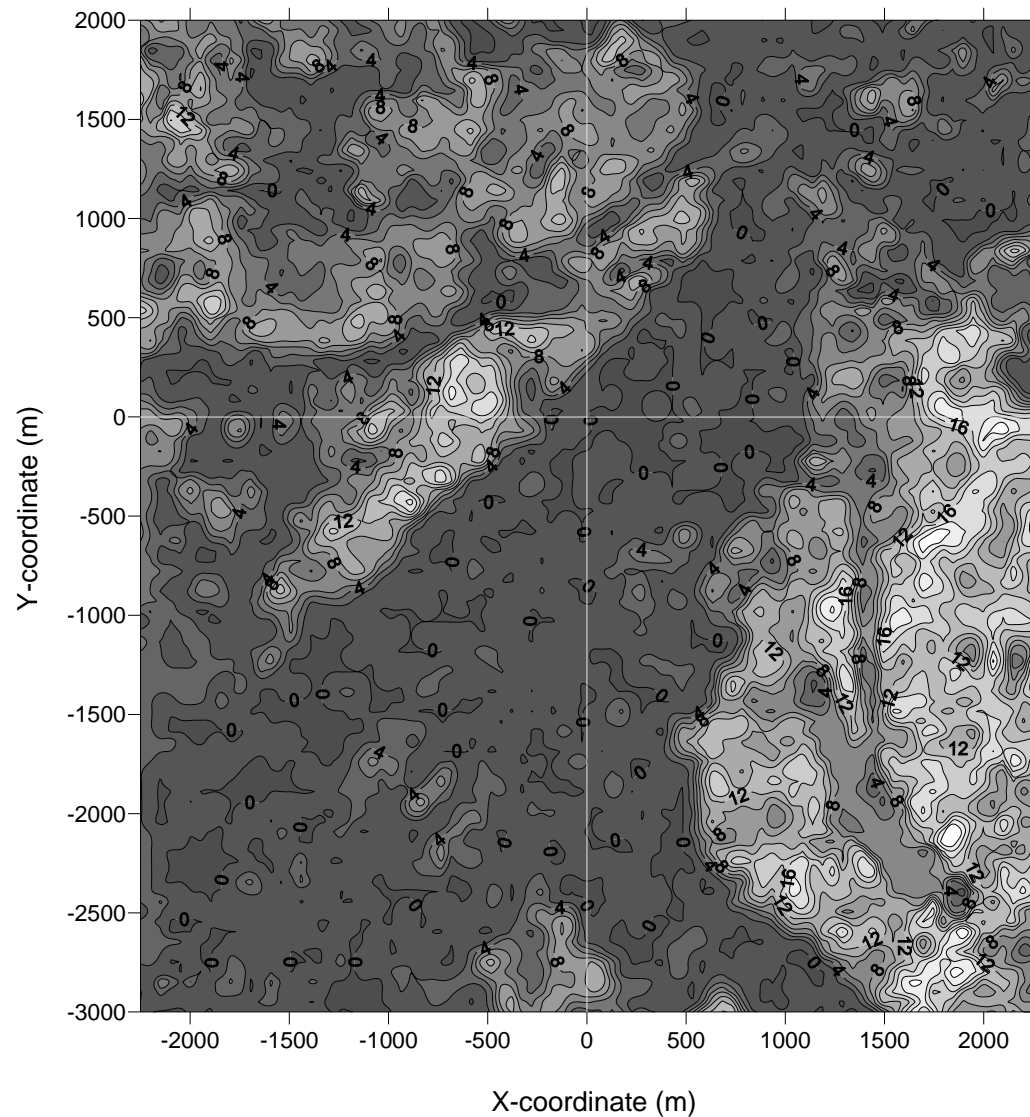


SRTM Data

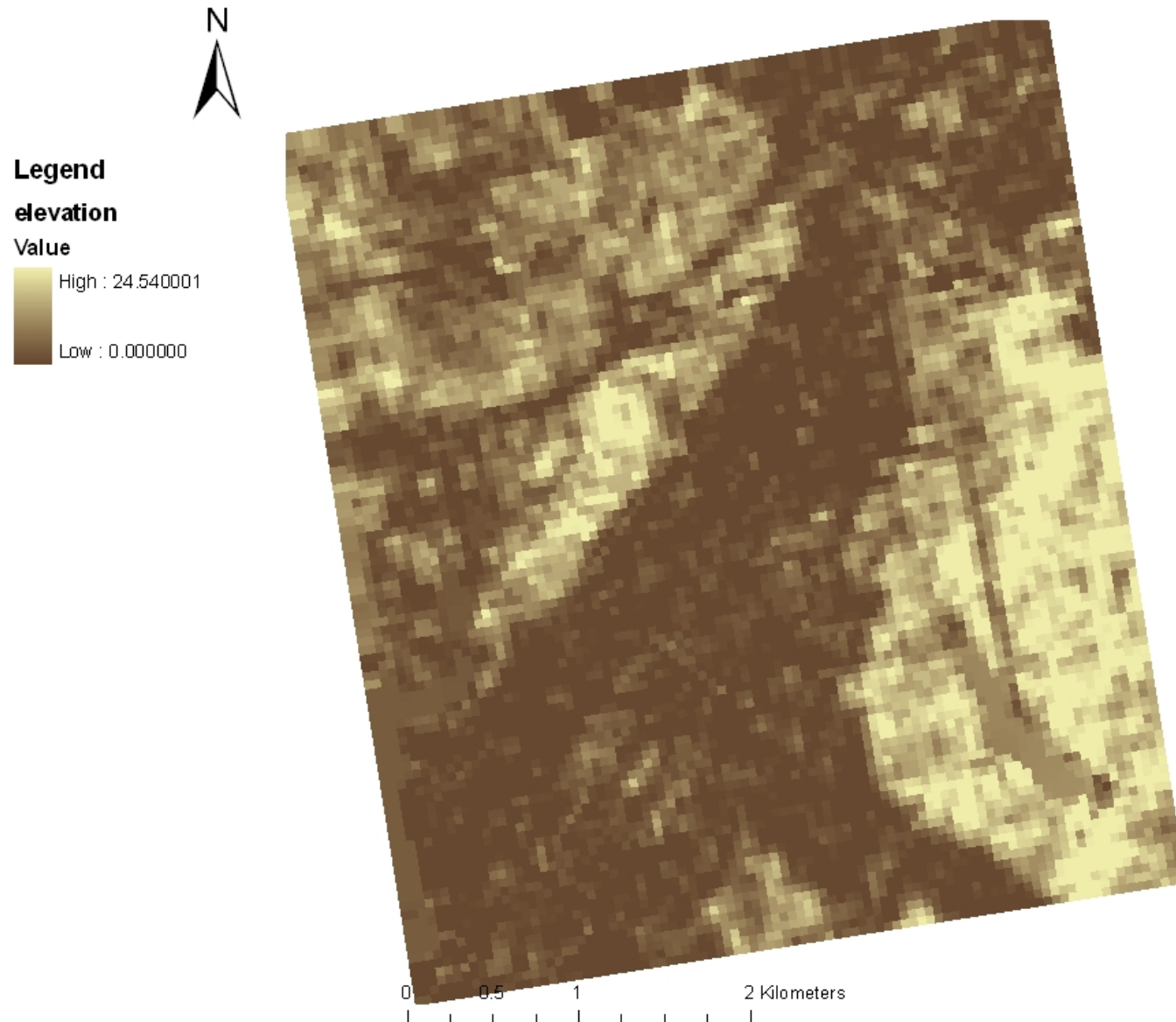


SRTM-NED Elevations for RDU

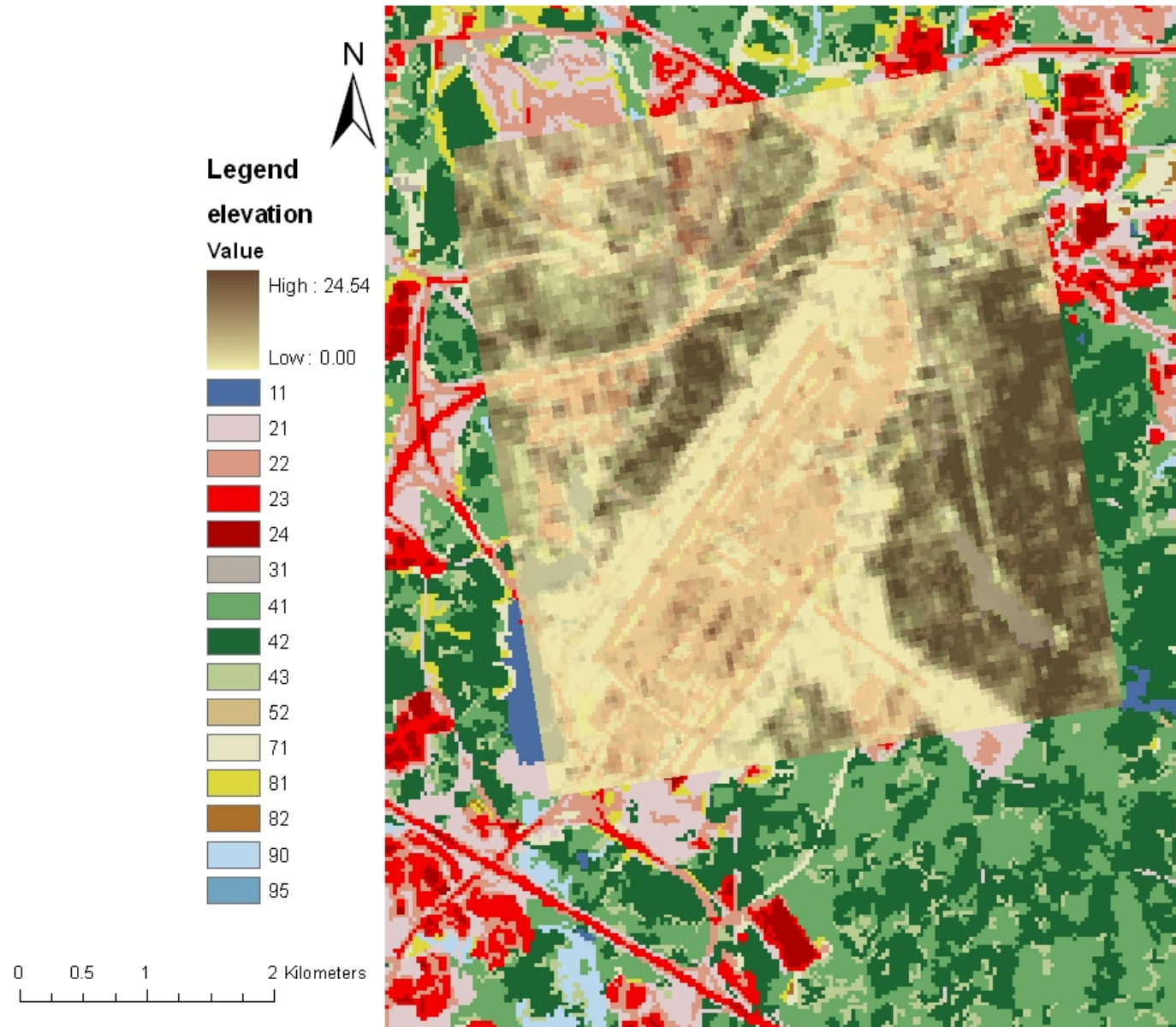
Contour Plot of Elevation Differences (m) from SRTM - NED Data
for Raleigh-Durham International Airport; Met Tower Located at (0,0)



SRTM-NED Elevations for RDU



SRTM-NED Elevations for RDU



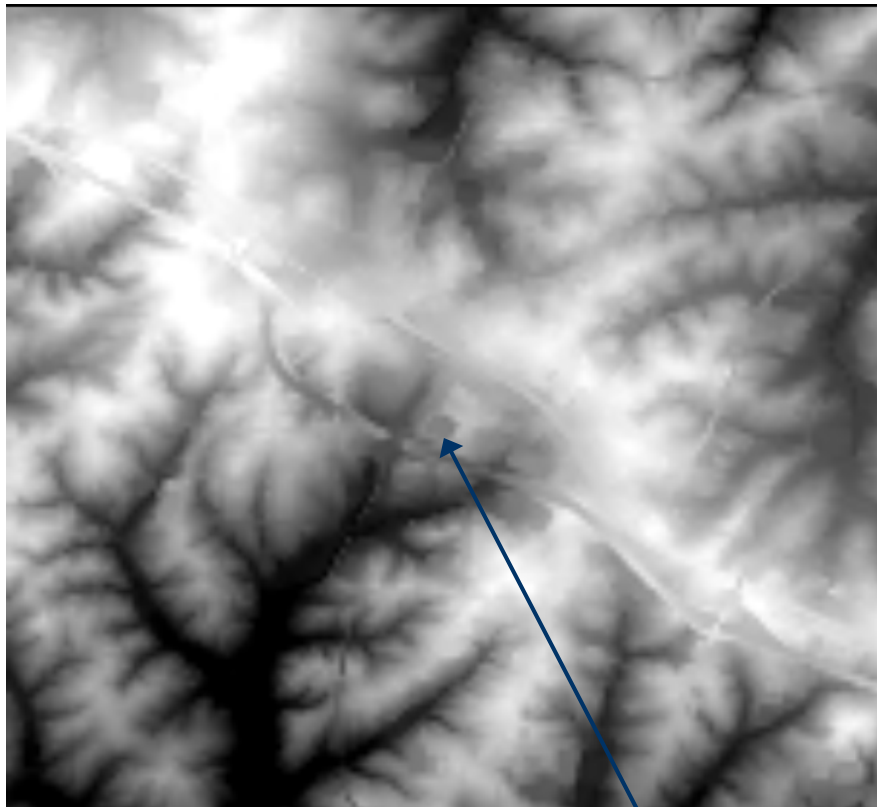
SRTM-NED Elevations for RDU



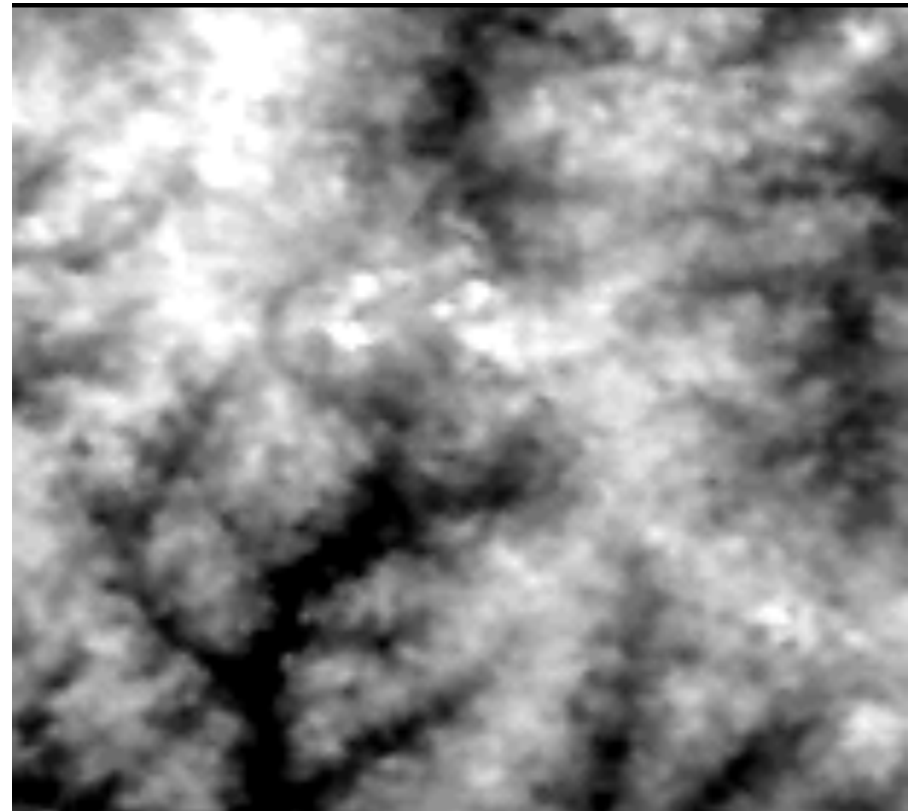
NED vs. SRTM Elevations for Durham

NED Data

SRTM Data



Durham Ballpark



Aerial Photo for Durham

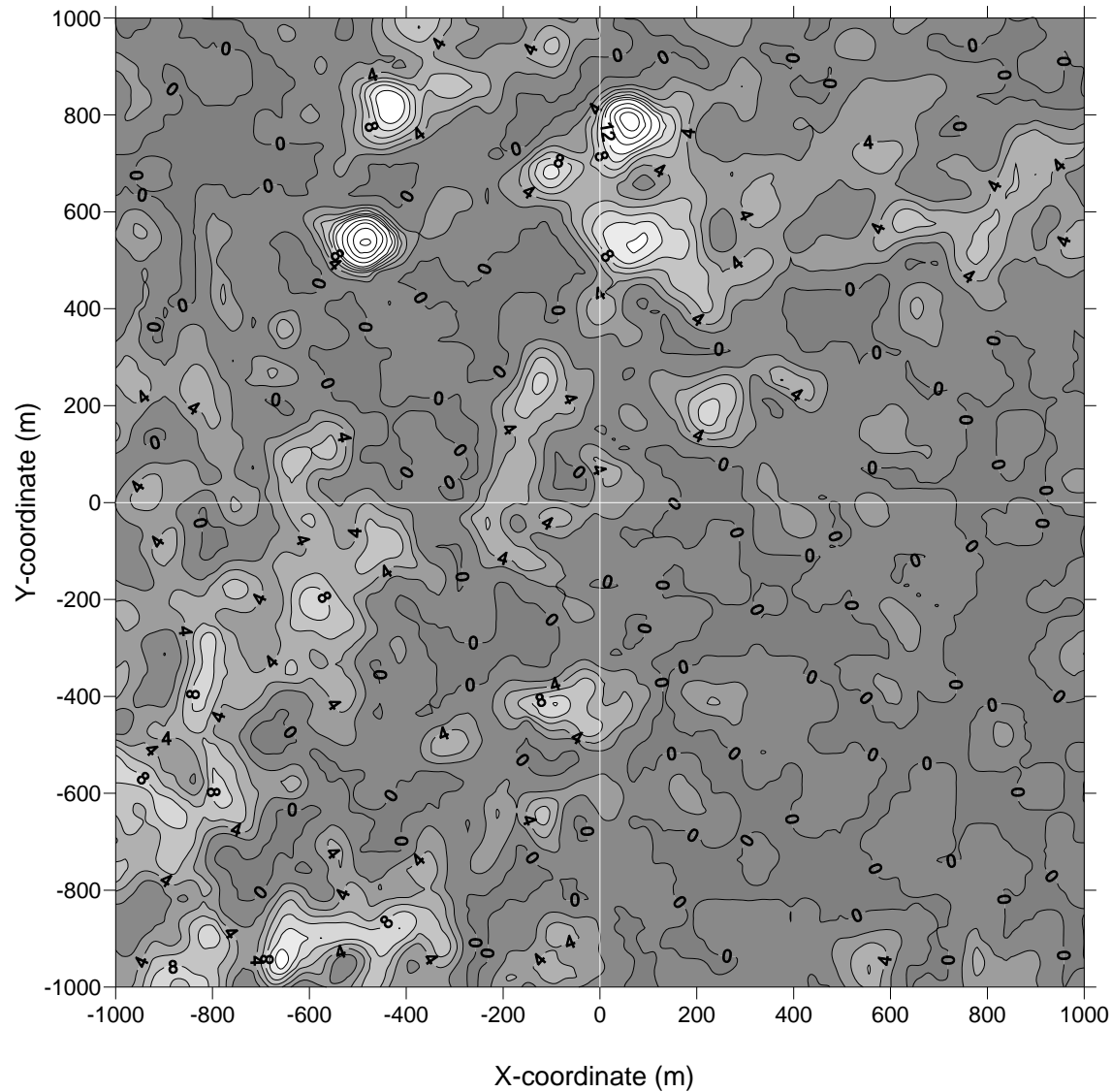


Legend

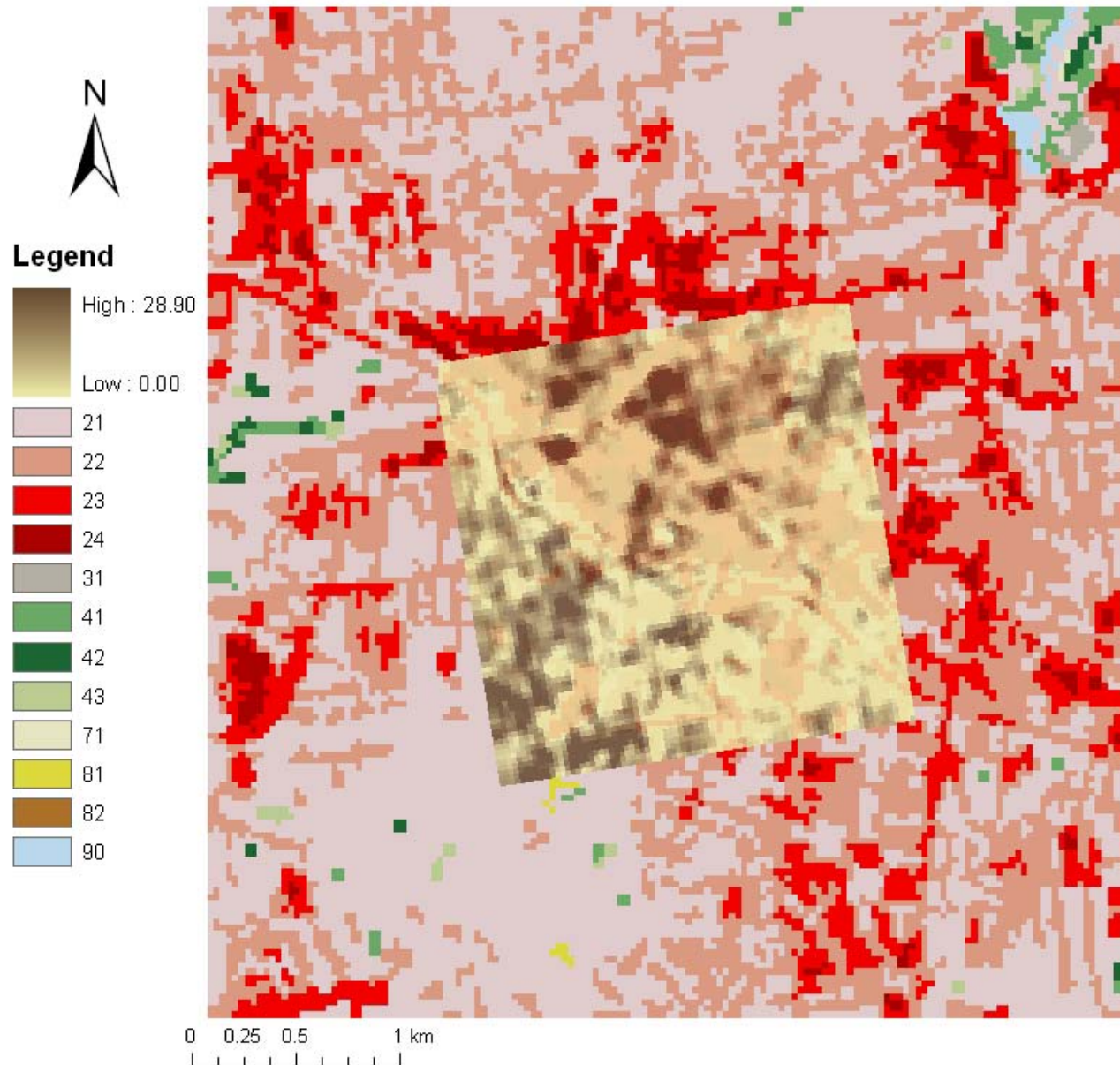


SRTM-NED Elevations for Durham

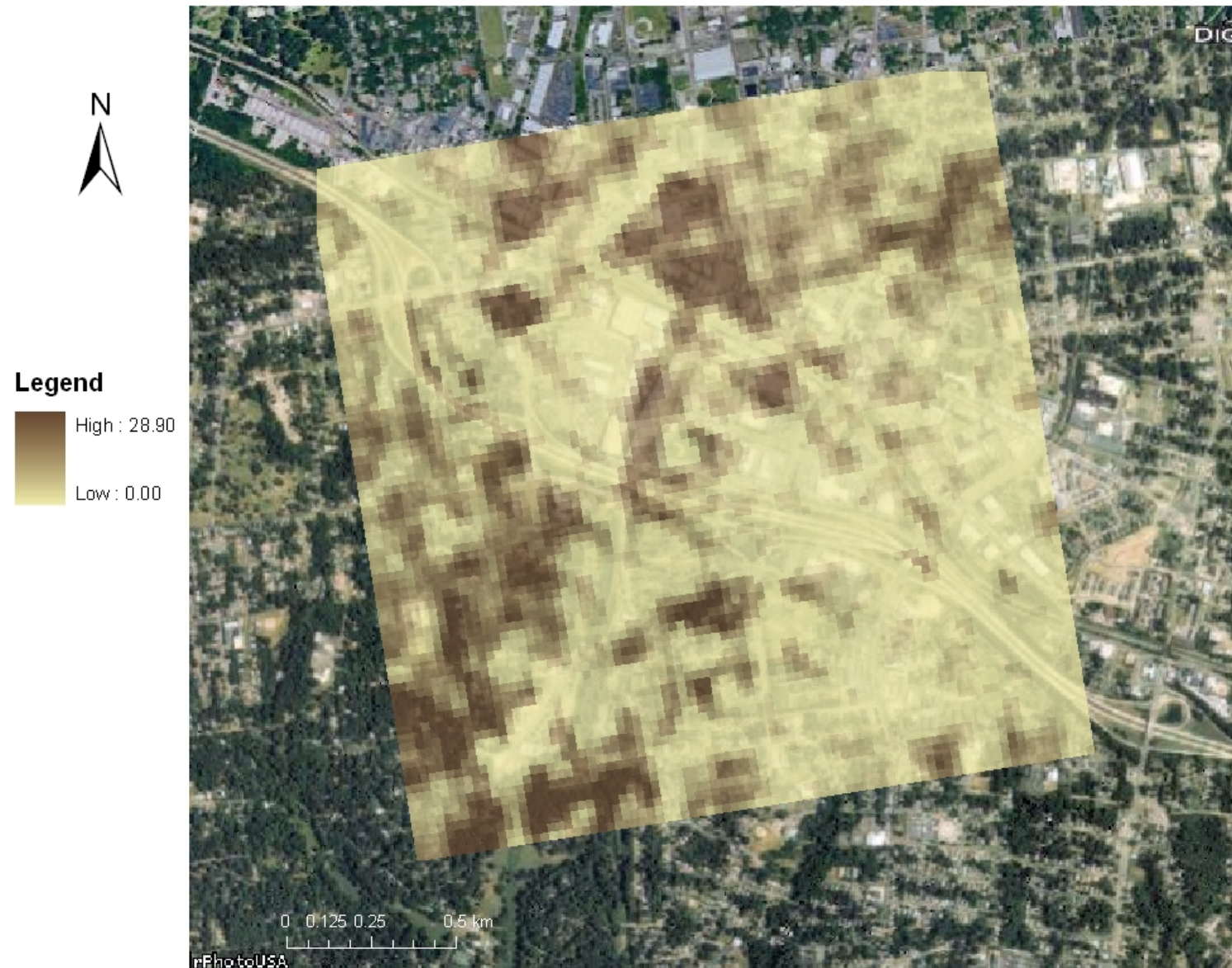
Contour Plot of Elevation Differences (m) from SRTM - NED Data for
Downtown Durham; (0,0) = Durham Ballpark - Corner of 1st Baseline



SRTM-NED Elevations for Durham

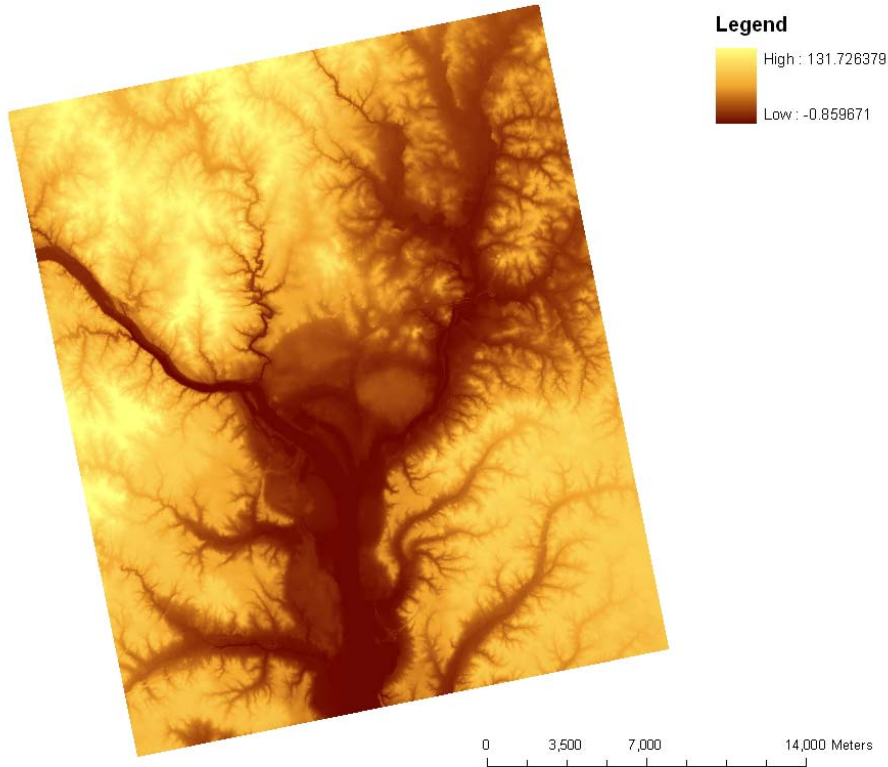


SRTM-NED Elevations for Durham

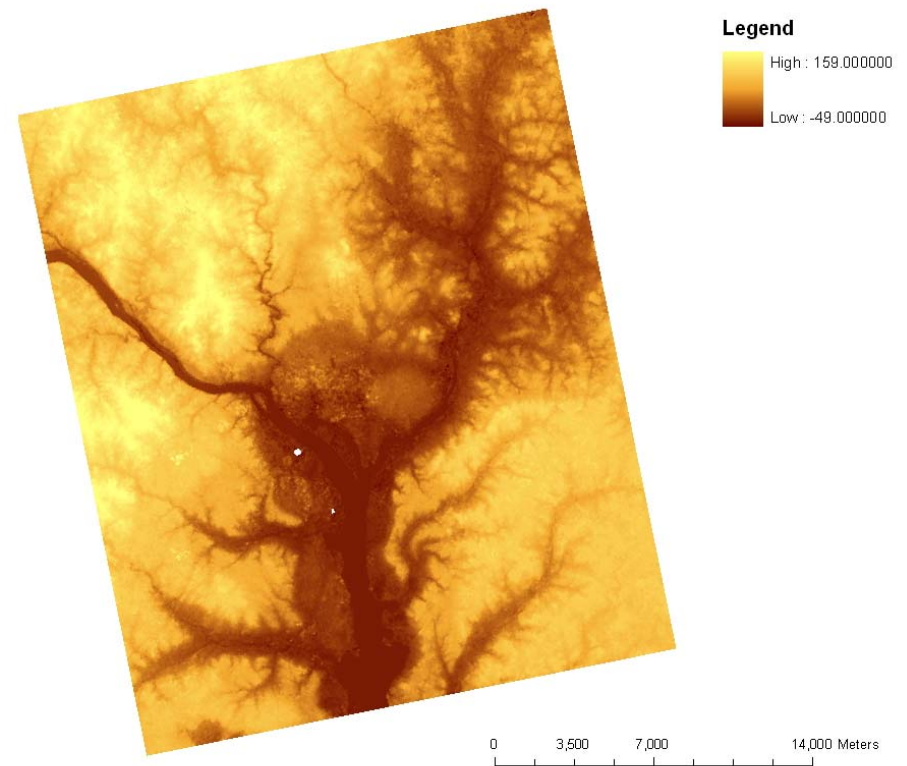


NED vs. SRTM Elevations for DC

NED Data

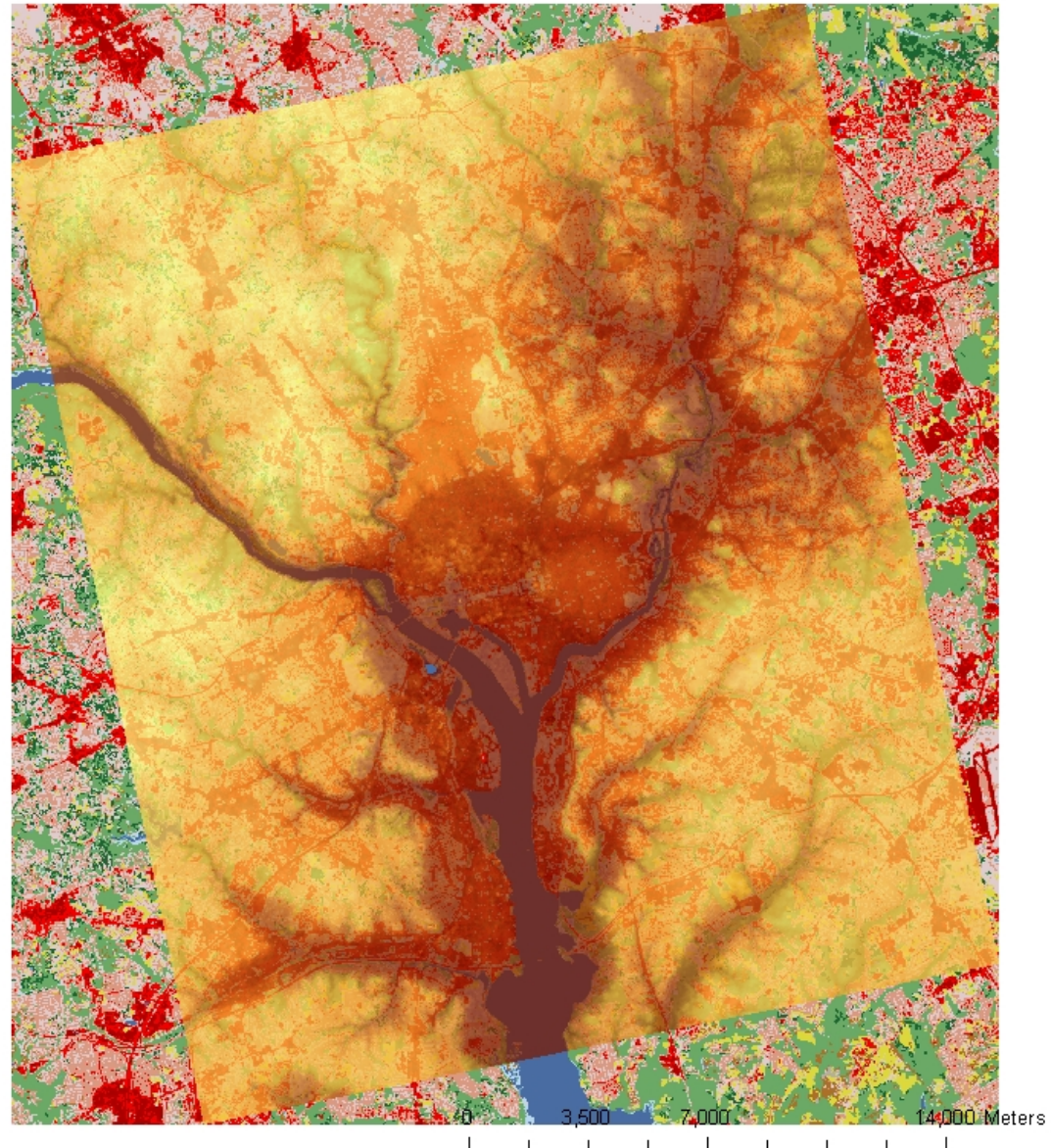
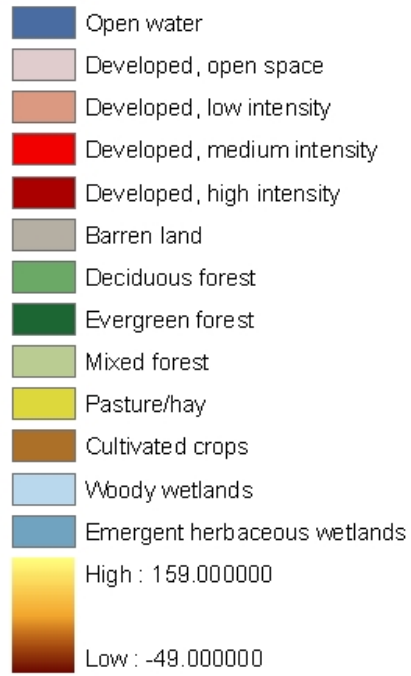


SRTM Data



SRTM and 2001 NLCD Data for DC

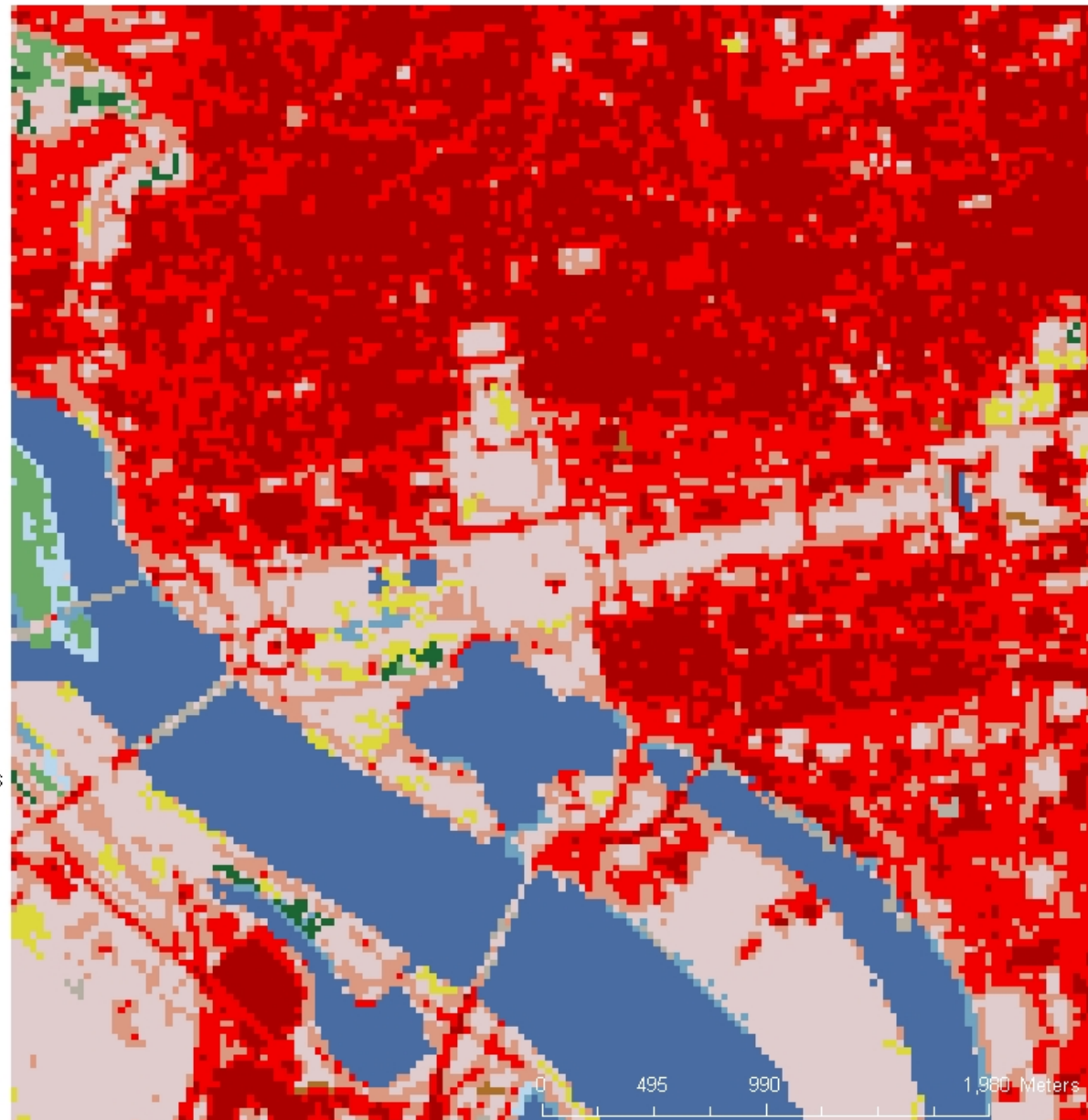
Legend



2001 NLCD Data for Downtown DC

Legend

- Open water
- Developed, open space
- Developed, low intensity
- Developed, medium intensity
- Developed, high intensity
- Barren land
- Deciduous forest
- Evergreen forest
- Mixed forest
- Pasture/hay
- Cultivated crops
- Woody wetlands
- Emergent herbaceous wetlands



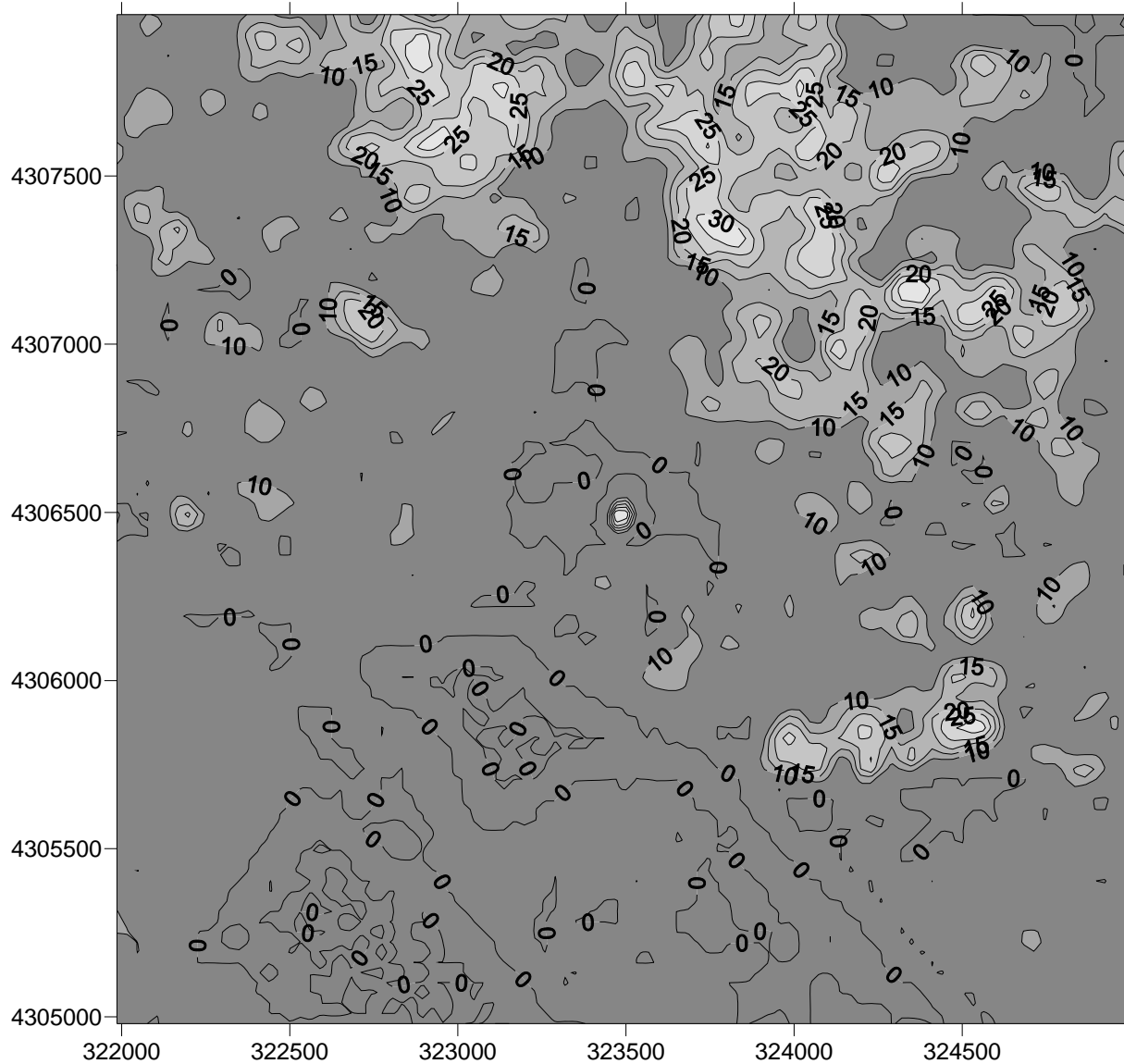
Aerial Photo of Downtown DC

Washington
Monument



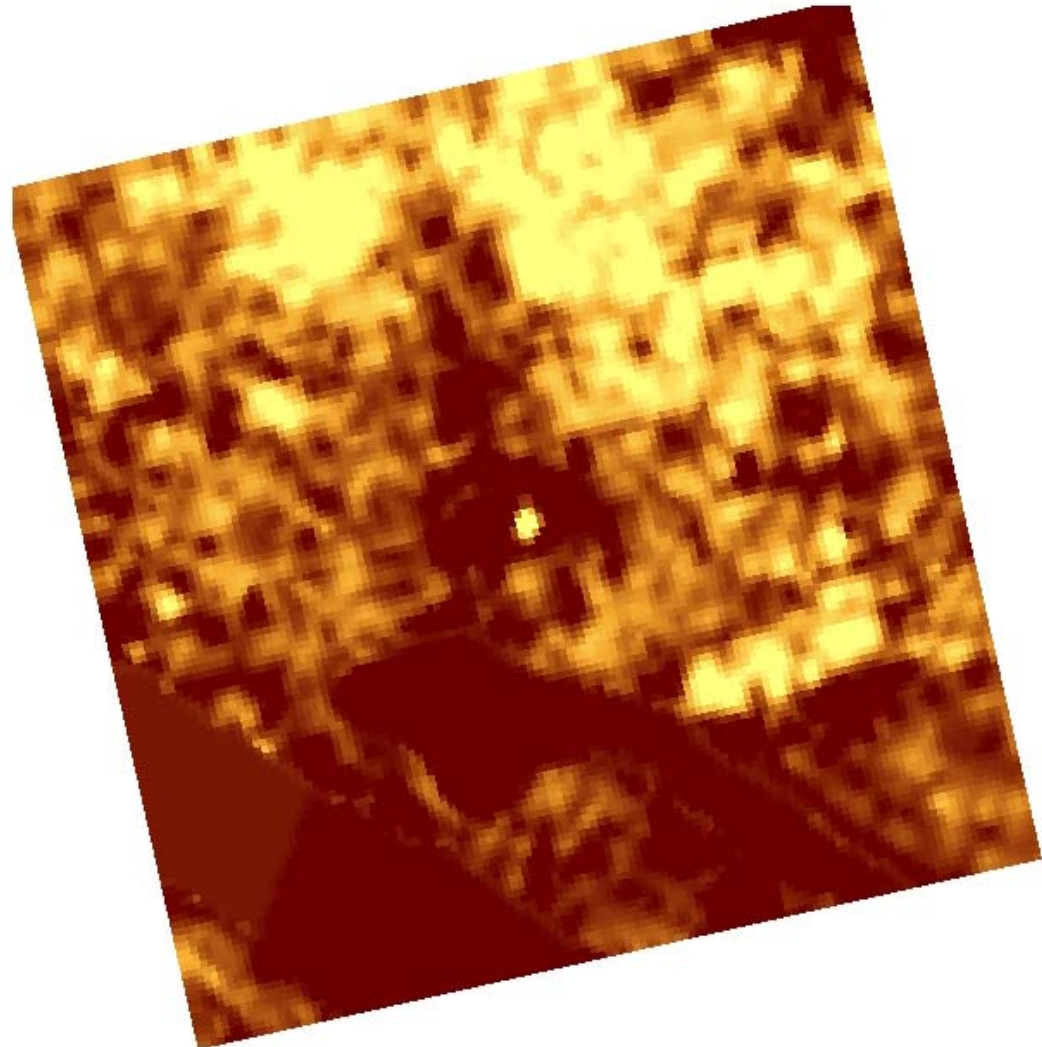
SRTM-NED Elevations for DC

SRTM-NED Elevation Differences (m) for Washington, DC



SRTM-NED Elevations for DC

Legend



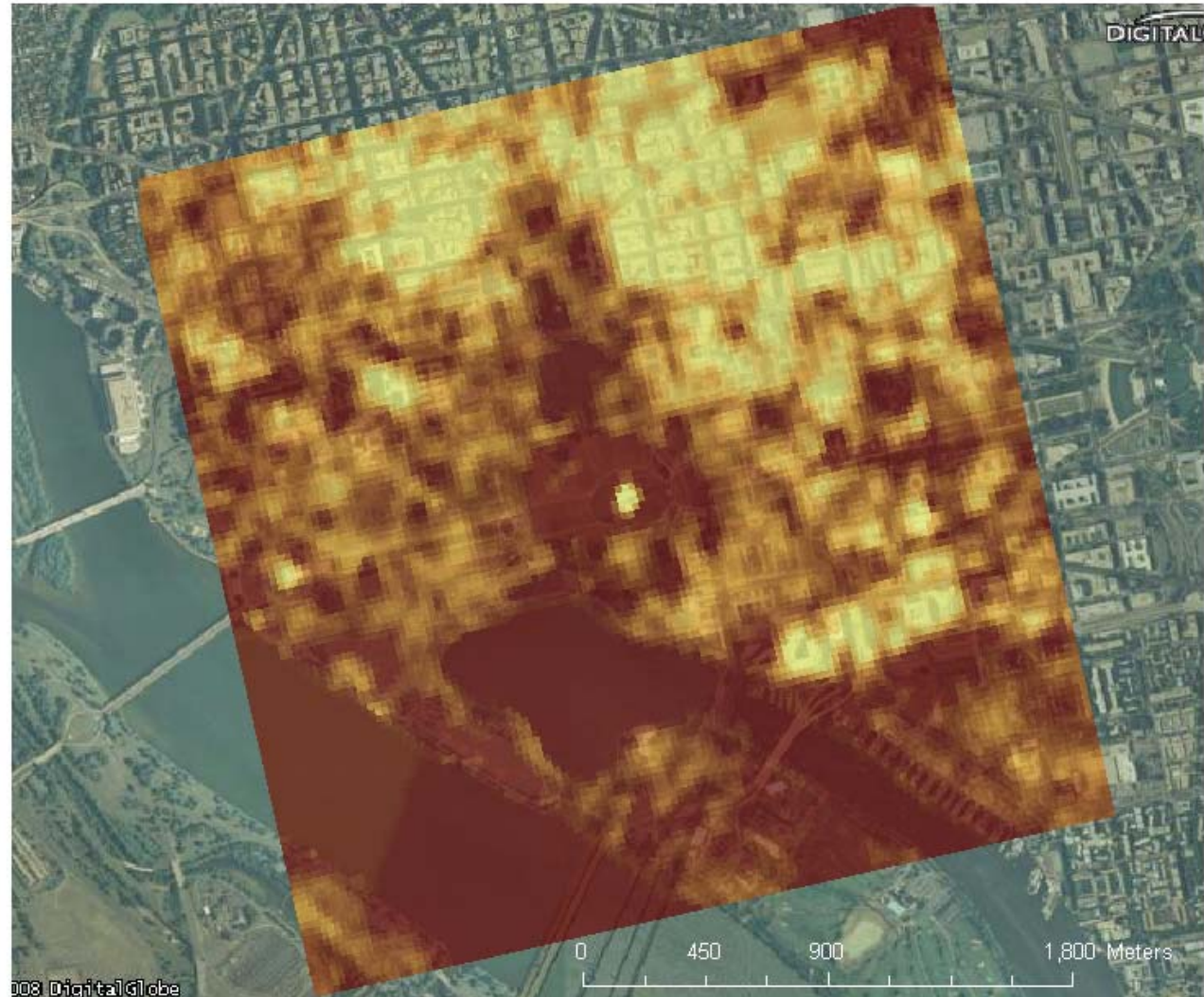
0 450 900 1,800 Meters



A horizontal scale bar with tick marks at 0, 450, 900, and 1,800 meters. The text '0 450 900 1,800 Meters' is placed above the bar.

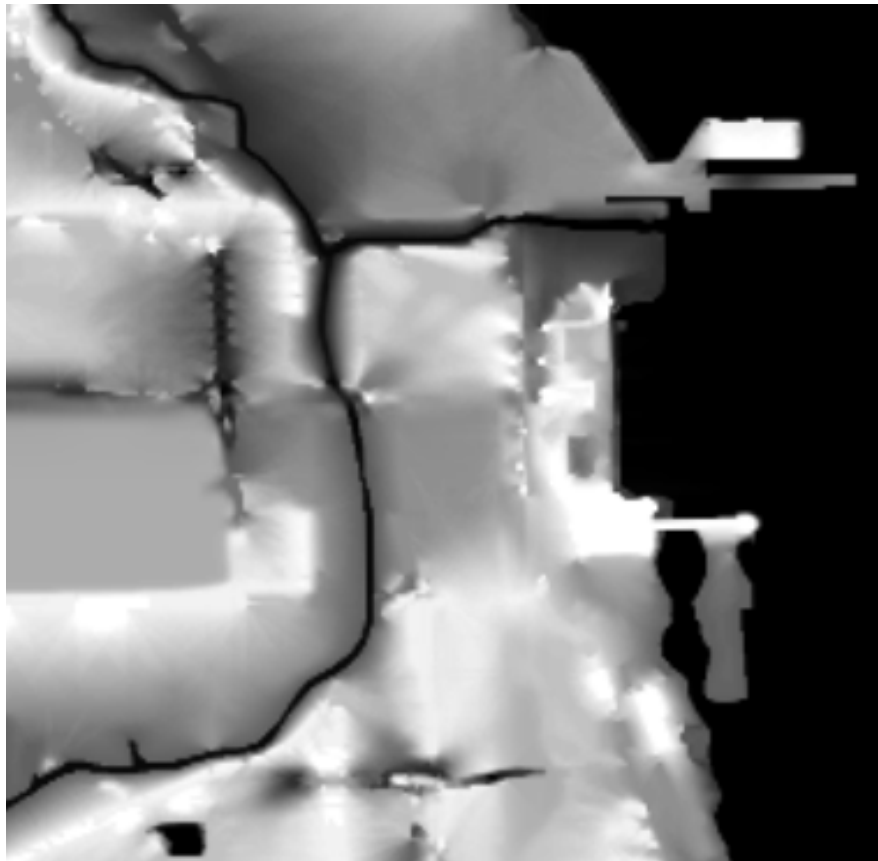
SRTM-NED Elevations for DC

Legend

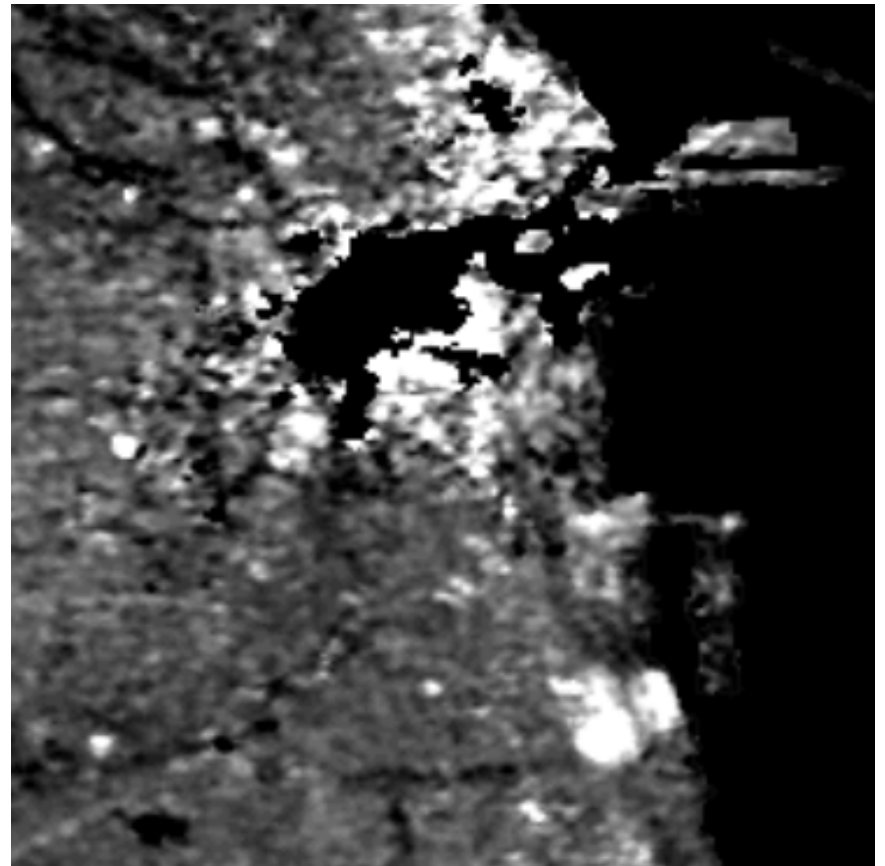


NED vs. SRTM Elevations for Chicago

NED Data

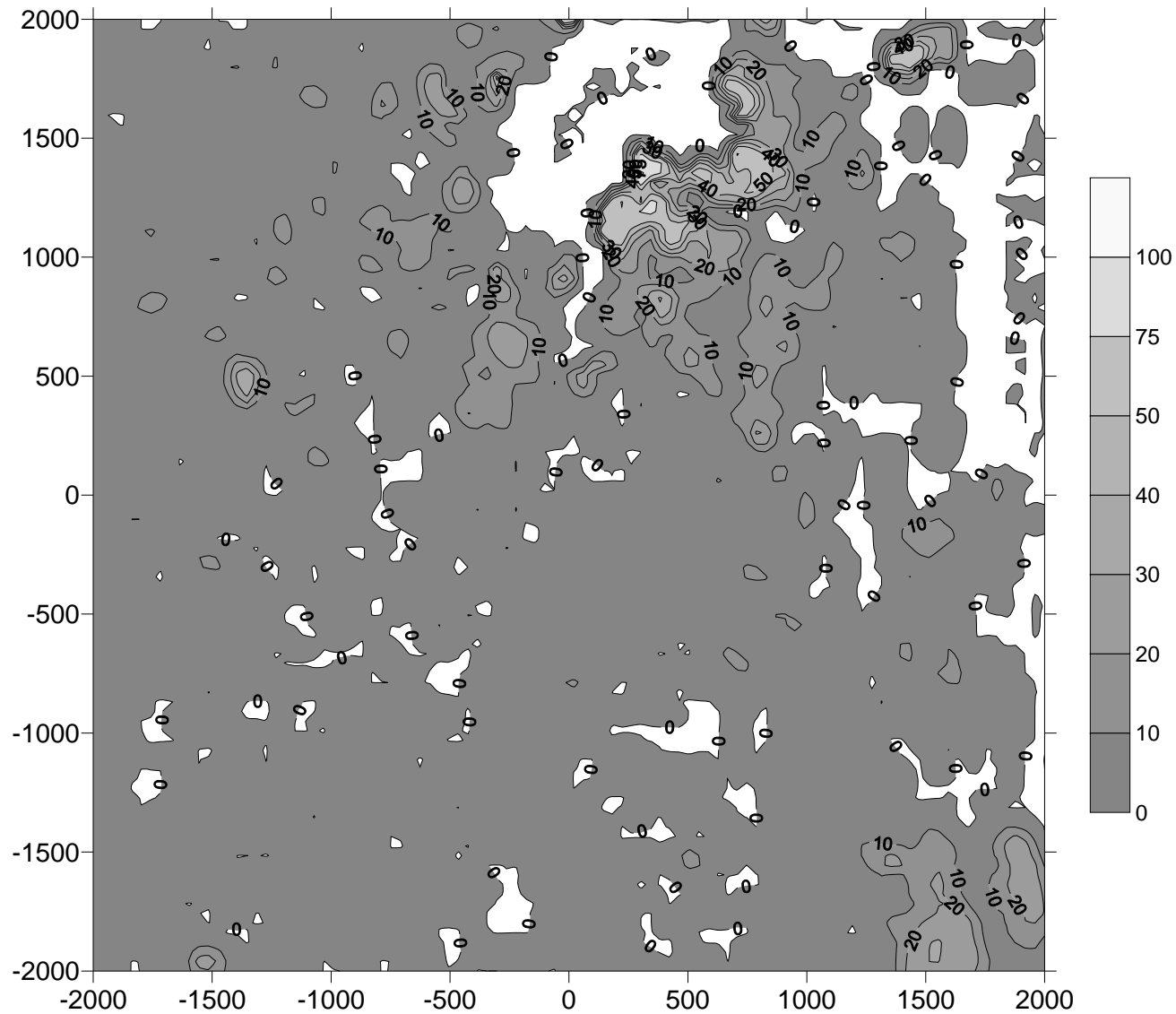


SRTM Data



SRTM-NED Elevations for Chicago

SRTM-NED Elevation Differences (m) for Chicago Area



Summary

- One of the main AERMOD implementation issues is sensitivity of meteorology to surface characteristics
- AERSURFACE tool provides an objective method for determining surface characteristics
- Challenges exist with applicability of NLCD data to our needs, but opportunities exist to improve on current approach
- Until recently, EPA dispersion modeling has been “data-limited”, but new data resources are shifting us to a more “data-driven” approach

Questions?